DOCUMENT RESUME

ED 302 665 CE 051 652

TITLE	Technology: A National Imperative.
INSTITUTION	International Technology Education Association, Reston, VA.
SPONS AGENCY	Technical Foundation of America, Lansing, IL.
PUB DATE	88
NOTE	30p.
AVAILABLE FROM	Publications Department, International Technology Education Association, 1914 Association Drive, Reston, VA 22091 ($8.00 members; $10.00 nonmembers).
PUB TYPE	Information Analyses (070)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Curriculum Development; Educational Attitudes; *Educational Innovation; Educational Needs; Employment Projections; *Futures (of Society); *Industrial Arts; Mathematics Instruction; Postsecondary Education; Program Improvement; Science Instruction; Secondary Education; *Technical Education; *Technological Advancement; Vocational Education

ABSTRACT

Many changes will occur in the United States in the next decade, often occasioned by new technology. Most new jobs will be highly technical and require technical education. At the same time, however, fewer workers with the required skills may be available as the U.S. work force becomes increasingly older, more female, and more disadvantaged. Technology has been described as the application of mathematics and science for specific purposes--to make life better. It also has been described as the use of knowledge, tools, and skills to increase our potential, to solve problems, and to modify the world. Faced with increasing technological change, schools are addressing many aspects of technology through a contemporary subject called "technology education." As part of the school curriculum, technology education teaches students to understand, use, and control technology. The curriculum covers the development of technology and its effect on people, the environment, and society. The increasing sophistication of the technological world has caused educators to address technology in conjunction with the study of mathematics and science. A curriculum has been developed and the parameters of technology education have been set. If parents, teachers, government officials, and corporate executives all play their parts, success in teaching technology education will result in a more educated populace that will provide the United States with the competitive edge necessary to remain as one of the most productive nations in the world. (KC)

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Technology
A NATIONAL IMPERATIVE

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A Report by the
Technology Education Advisory Council

Technology
A NATIONAL IMPERATIVE

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Foreword

Technology: A National Imperative brings attention to the increasingly important role that technology plays in our society and how it effects our everyday existence. The publication, written by a group of business, industry, and education leaders, makes the point that we are living in a unique age, a time of unprecedented change—change brought about by technology.

Technology has been described in many ways. But most definitions concur that technology is the application of math and science for specific purposes . . . to make our lives better, more productive or more enjoyable. Technology has also been described as the use of knowledge, tools and skills to increase our potential, to solve problems, to modify our world.

In itself, technology is rigid and inhuman. It offers no solutions. Managed, technology is flexible. Understood, it can be adapted and changed as needed—or wanted.

Many aspects of technology are being addressed in our schools through a contemporary subject area called—Technology Education. As part of the school curriculum, Technology Education teaches students to understand, use, and control technology. The curriculum covers the development of technology and its effect on people, the environment and society. In this course, students learn how to adjust to change, to deal with forces that influence their lives, and to participate in controlling their future.

The increasing sophistication of our technological world has caused us to have to address technology in conjunction with the study of mathematics and science. This publication draws attention to the reasons why we need to study technology in our society and schools. It addresses what technology is and is not, what Technology Education is, why it is important to youth of the world, and how it can assist in keeping countries in a competitive posture. Finally, it contains a call for action for there is much that can be done toward creating an understanding of technology in our schools.

The issue is not whether technology or Technology Education is good or bad; not whether it should or shouldn't be offered; or not how it is to be taught. The issue here is whether the United States will maintain its worldwide competitive lead in technology. Obviously, our country wants to maintain its superiority as a leader in technology. Understandings and education pertaining to technology will assist us in keeping the quality of living that we desire. This publication is about providing a form of education that will help our citizens live optimally in an advanced technological society.

Walter B. Waetjen
Chairman, Technology Education Advisory Council
President Emeritus, Cleveland State University

Technology Our Key to Prosperity

The year 2000 will mark the end of what has been called the American Century. Since 1900, the United States has become wealthy and powerful by exploiting the rapid changes taking place in technology, world trade, and the international political order. The last years of this century are certain to bring new developments in technology, international competition, demography, and other factors that will alter the nation's economic and social landscape. By the end of the next decade, the changes underway will produce an America that is in some ways unrecognizable from the one that existed only a few years ago.

Four key trends will shape the last years of the 20th century:

- The American economy should grow at a relatively healthy pace, boosted by a rebound in U.S. exports, renewed productive growth, and a strong world economy.
- Despite its international comeback, U.S. manufacturing will account for a much smaller share of the economy in the year 2000 than it does today. This will be due to low productivity resulting from the lack of qualified personnel capable of implementing current and new technology. Service industries, requiring highly skilled technical personnel, will create all of the new jobs, and most of the wealth, over the next 13 years.
- The workforce will grow slowly, becoming older, more female, and more disadvantaged. Only 15 percent of the new entrants to the labor force over the next 13 years will be native white males, compared to 47 percent today.
- The new jobs in service industries will demand much higher technical skill levels than the jobs of today. Very few new jobs will be created for those who lack adequate science/technical knowledge and who cannot read, follow directions, or use mathematics. Ironically, the demographic trends in the workforce, coupled with higher skill requirements of the economy, will lead to both higher and lower unemployment: More joblessness among the least skilled and less among the most educationally advantaged.

These trends raise a number of important policy issues. If the United States is to continue to prosper—if the year 2000 is to mark the end of the first American Century—policy makers must find ways to: (1) stimulate balanced world growth; (2) accelerate productivity increases in manufacturing and the service industries; (3) maintain the dynamism of an aging workforce; (4) reconcile the conflicting needs of women, work, and families; and (5) improve the technical education preparation of all workers. As the economy grows more complex and more dependent on human capital, the standards set by the International Technology Education Association must be raised and restructuring of the total system must take place.

As the economies of developing nations move further into the post-industrial era, human capital plays an even more important role in their progress. As the society becomes more complex, the amount of technical education and knowledge needed to make a productive contribution to the economy becomes greater. A century ago, a high-school education was thought to be superfluous for factory workers and a college degree was the mark of an academic or a lawyer. Between now and the year 2000, for the first time in history, a majority of all new jobs will require post-secondary education.

Education and training are the primary systems by which the human capital of a nation is preserved and increased. The speed and efficiency with which these education systems transmit knowledge governs the rate at which human capital can be developed. Even more than such closely watched indicators as the rate of investment in plant and equipment, human capital formation plays a direct role in how fast the economy can grow.

If the economy is to grow rapidly and American companies are to reassert their world leadership,

the educational standards that have been established in the nation's technical schools must be raised dramatically. Put simply, students must go to school longer, study more, and pass more difficult tests covering advanced subject matter. There is no excuse for vocational or technical programs that "warehouse" students who perform poorly in academic subjects or for diplomas that register nothing more than years of school attendance. From an economic standpoint, higher standards in the technical schools are the equivalent of competitiveness internationally.

Promoting world growth, boosting service industry productivity, stimulating a more flexible workforce, providing for the needs of working families with children, bringing minority workers into the workforce, and raising educational standards are not the *only* items in the nation's agenda between now and the year 2000. But they are certainly among the most important.

More critically, they are issues that will not go away by themselves. If nothing is done to focus national attention and action on these challenges, they are likely to be still unresolved at the beginning of the next century. By addressing them now, the nation's decision makers can help to assure that the economy and the workforce fulfill their potential to make the year 2000 the beginning of the next American Century.

The world is on the edge of a major lifestyle, business, industry, and educational upheaval—an upheaval which will be fueled by rapid technological growth and by a very competitive worldwide marketplace. This upheaval brings with it major threats and opportunities to the business and economic base of the United States—all of which is predicated on the technological literacy of our citizens.

Between now and the year 2000, a number of powerful economic forces will reshape American jobs and industries. the most important trend will be:

- Continued integration of the world economy
- Further shifts of production from goods to services
- The application of advanced technologies to most industries
- Faster gains in productivity, particularly in services
- Disinflation or deflation in world prices
- Increased competition in product, service, and labor markets

In varying degrees, the patterns that will shape the future are visible in recent economic history.

The path of the United States economy over the next 13 years will depend substantially on events and decisions elsewhere in the world. The rate at which the world economy grows and the competitive actions of other nations will be as important as actions taken in the United States. Without rapid world growth in both developed and developing nations, the United States cannot hope to sustain strong growth at home. And unless American productivity rises more rapidly than that of its principal competitors, domestic economic growth will lag behind other nations.

Over the past 25 years, the U.S. economy has closely mirrored the world economy. With few exceptions, in years in which the world has been booming, the United States has been booming; when the world has been in recession, so too has the United States.

The reason for the tight linkage is straightforward: As trade grows in importance, it accounts for more U.S. growth. When Japan expands rapidly, it buys more Boeing jets for Japan airlines, uses more American medical instruments in Japanese hospitals, and sends more wealthy Japanese tourists to visit the United States. Just as rapid growth in California's Silicon Valley created jobs in Michigan auto plants and New York investment banks, so growth in Japan and Korea has created jobs in San Francisco hotels and Seattle aircraft plants. The market for U.S. goods and services has grown to include not only the 50 states, but also the 178 countries of the world.

As obvious and remarkable as these observations may be, they have been widely ignored in recent debates concerning the nation's economic future. Much discussion of competitiveness, trade balances, and other measures has focused exclusively on the U.S. position relative to the rest of the world and has failed to recognize the overwhelming interest we have in the economic success of other nations. The real challenge for the United States is to increase its own productivity, while stimulating maximum world growth—not to capture economic activity from other nations.

Put simply, the Japanese, the Germans, the Koreans, and the Brazilians are not stealing American jobs—they are creating them. Just as Korea or Brazil profits from strong growth in Europe and North America, so the United States gains from growth in Asia and Latin America. More important than the competition among nations for high-productivity industries and good jobs is the collective effort to maximize world growth. The world is not a zero-sum game in which the U.S. must level the playing field in order to win a fair share of jobs. Instead, United States self-interest dictates that it stimulate the economies of other nations, since this is the most important way of creating American jobs.

Based on the preceding projections and facts, let us now examine other factors that must be considered if the United States meets the challenges of the 21st century.

Because the American culture is distinctly characterized as technological, it becomes the function of our educational system to provide every student an insight and understanding of the technological nature of the culture. All persons must be knowledgeable of their technological environment so they can make rational decisions about their own lives on a day-to-day basis and participate in controlling their own destiny.

As technological development continues at an accelerated rate, it will become increasingly more difficult for people to understand these changes.

Extreme action must be taken to prevent us from becoming a technologically illiterate nation. It is absolutely necessary for all people to understand technology if they are to function as citizens in their role as voters, workers, employers, and family members. A concentrated effort is essential to educate the citizens of our nation to better understand technology and its impact on their lives. Only then can technology be controlled and contribute to advancing our way of life. This endeavor must begin in the secondary school system at the primary level, continue through the institutions of higher learning, and be promoted by the continuing education network.

Technological advancement and world economics together determine the leadership positions of countries in the world today and will become more prevalent at the turn of the century. As a nation, we must address the problem of providing adequately trained personnel to guide our technological growth in all industries. This effort must include industry, academia, and government in a partnership designed to support a technologically literate, creative, and innovative society.

The "real world" wealth of nations lies in their human resources. Nations that have placed their confidence in the capability of their men and women to create have done well in recent years. When we look at Japan, Malaysia, Taiwan, Korea, Holland, Israel, and even Hungary, we see countries that have few resources to speak of, very little land, very little capital, and, for the most part, limited population. But they have adapted in an extraordinary way to technological change and to the new industrial revolution that is sweeping the world by bringing into the market new types of products, services, and ideas. On the other hand, when we look at countries like Brazil, Mexico, Australia, Zaire, the Soviet Union, and certain regions of the United States—countries the size of continents, full of natural resources—we find regression.

The "real world" economy will more and more put a premium on intelligence, creativity, discipline, excellence, and especially the "human factor."

Herein lies the crucial need for a national strategic approach to restructuring the educational systems of the United States. Such a restructuring would provide individuals with the basic thinking and creative skills required in the 21st century: Communications, problem-solving, scientific and technological literacy. The key for economic competitiveness in the global marketplace today and in the future is "*productivity*." This can only be accomplished if we have excellence in Technology Education.

The Nature of the Technological Society

"There is no human nature, there is only history."
Ortega y Gasset

Introduction

The human story has always included technology. From the beginning, people have been makers and users of tools, homo faber, but surely historians will note the remarkable strides in our times. In a single century the world has been made electric and atomic. It is a world of chemicals and machines; roadways are overarched by airways, and a vast communications network can connect the world together in an instant. The nature of our technological society is marked by unrelenting change, so much so that some social critics question humankind's ability to cope. Thus technology, for all its benefits, poses social dilemmas and at times we may believe at best we can only endure its vagaries. And yet, technological change is vital to growth, perhaps inevitable as the world must support a burgeoning population. Far better that each person should understand and contribute to the evolution of technology in society. What is imagined and considered controls our reality. The control of technology must be informed and value-based. Only then will technology truly serve the society that generates it. The nature of such a technological society would be that it has become natural.

Technology and Society

Technology affects society and society affects technology. The nature of a technological society is determined by the balance and control exercised for these links and the uses society chooses for its technology.

The effect of technology on society can be shown with countless examples. Early agriculture emerged when the digging stick was modified into a tool to make furrows and humans changed from hunter/gatherers to settled farmers. Metal technology, first used for ornaments and weapons, was later the basis for a social statement—"making swords into plowshares." Thus it became an example of society affecting technology, since the use of a valued technology was deliberately diverted from war to agriculture, and the artisans had to learn to make and shape much larger pieces of metal. These technology-society links are best revealed by history and hindsight. Frequently the outcomes are unexpected or surprising. The printing press, the harnessing of steam, the discovery of the microbial world—all had profound effects on society. Sanitary engineering and the evolution of medical practice led to the population explosion, surely not foreseen by the early practitioners who believed only they were saving lives. The rate at which these remarkable and often unforeseen effects of technology took place on society was rapid in an historical perspective but slow by modern standards.

The kind of society found in late 20th-century America is to a signficant degree a product of modern technologies derived from perceived human needs, military or defense requirements, and occasionally from pure imagination. In our times, however, an unprecedented technological compounding has occurred, one new technology building on another or built from various combinations of existing technologies. This gives rise to the seeming explosion of technology in society. Compounding over a lifetime generates an accelerating change and the often difficult challenge to participate or cope.

Impact in the Workplace

Nowhere is change more apparent than in the workplace where hard-won skills and knowledge become obsolete, perhaps several times during a lifetime, and new skills must be learned—a welcome challenge to some and a path to weariness for others. Until this century, most people could learn a skill or become educated for a profession and expect that learning to last their lifetime. No longer is this true.

Reaction to this change may be rejection or the proposal of alternate cultures. The "small is beautiful" movement of the 1960s is an example. Yet another reaction is the development of subcultures, some of which are very anti-social, ranging from street criminals to international terrorists. Unfortunately, technology is available to these subcultures and can have momentous effects: for example, Hitler's war machine or the great leverage of

HISTORICAL VIEW
RESPONSE TO NEED CONSTRAINTS
THE RATE OF CHANGE EFFECT
GLOBAL VIEW
ACCOMMODATION • COOPERATION •
MILITARY DEFENSE
PRESENT/FUTURE VIEW
APPLICATIONS OF TECHNOLOGY •
RESULTS • PROBABLE • UNEXPECTED
VALUES
RISKS • BENEFITS • COSTS •
BAD/GOOD • ETHICS • LAW
RESPONSES • EMOTIONAL • OBJECTIVE
VIEWS/VALUES PLANE
CRAFTS • TECHNOLOGY • APPLIED SCIENCE •
TRADES • ENGINEERING • BASIC SCIENCE
FABRICATION • SYSTEMS • KNOWLEDGE •
OPERATORS • DESIGN • UNDERSTANDING
HANDS-ON • DOING • THINKING • MINDS-ON
DATA • FACTS • ROTE • CONCEPTS • CREATIVITY
THE TECHNICAL FIELD
BIOTECHNOLOGY • COMPUTERS • AUTOMATION •
ENERGY • MATERIALS • AGRICULTURE • MEDICINE •
SPACE • ARTIFICIAL INTELLIGENCE • FOOD •
INFORMATION • TECHNOLOGIES • ROBOTICS •
TRANSPORTATION • COMMUNICATION • PHOTONICS •
ELECTRONICS • PSYCHOLOGY • MANUFACTURING
THE TECHNICAL PLANE
THE SOCIAL SYSTEM
CONSTRAINTS • VIABILITY • HEALTH • GOOD LIFE •
GROWTH • STRENGTH • SAFETY • COMFORT
THE ECONOMIC SYSTEM
USES OF TECHNOLOGY • ZERO SUM • JOBS • WIN/LOSE
COMPETITION • COLLABORATION • INNOVATION
THE ENVIRONMENT
EFFECTS (GOOD-BAD) • FREE/USABLE • CLEAN
CULTURE • RECREATION • LEISURE
MIND • BODY BUILDING • FUN • GAMES • CHALLENGES
THE SOCIAL PLANE

Technology cannot be viewed apart from its interactions with society and the values of society. Figure 1 represents technology, society, and values as self-consistent planes of notions that intersect in myriad ways. Thus, for example, at one intersection, new technology that changes manufacturing methods will affect jobs or the skills and education needed to perform them, and at another may generate concern and debate over the rate at which those changes should be introduced. The figure is an idealistic generalization that shows technology as a human adventure, at once technical and serving human purposes. Technology is the process in this adventure—the shaping, making, and doing—so that foremost its nature in the technological society is replete with action. The multitude of constantly ongoing intersections of the technical system with our social system and our value system is at the root of why we perceive our technological society in so many different ways.

weapons in the hands of a few terrorists.

The magnitude of this rejection or aberrant adaptation to technology is simply too great to deny that it is a part of the nature of a technological society. It presents a continuing challenge to productive citizens who would use technology to live and work in peace.

And yet, most people do find positive ways to adapt—from simple coping to vigorous participation. Few would want to give up modern medicine, entertainment, communications, transportation, interesting work—all products of our technological society. Societies worldwide are eager to adopt them when they can. For most of us, the benefits far outweigh the costs.

Historically, new technology has been a stimulus for new enterprises and new jobs. In the U.S., the burden of adapting to changes in the workplace has fallen on the individual. Each must seek the appropriate education or training and find new employment. In other societies, assistance or even forced training and relocation are common. Competition in a global economy has even led some countries to invent socioeconomic mechanisms to win new markets. Businesses and individuals must work within a nationally prescribed system that transcends even major single industries to achieve national goals.

Benefits and Risks of Technology and the Response of Society

Just as in the workplace where technology brings a mixed bag, so does it with the overall surroundings of human life. The abundance of material goods inevitably produces toxic wastes; health care brings ethical dilemmas; abundant energy a threat to the environment. Each benefit has its risks, its trauma, and its unknowns.

Technology may bring great benefit to some, yet put others at risk or perceived risk. This has led to still another characteristic of the technological society—the unequal distribution of benefits and costs of technical change. Although taxpayers pay fair shares for roads and libraries, only those who use them benefit directly. A landfill will serve many people as a waste disposal facility, but the pollution of groundwater may affect only those who live within a few miles of the site. There are many examples of this issue for which the social system has few if any answers.

As problems arise from technology, new technology is often developed to overcome or mitigate the problems. In the case of smog in our cities, catalytic converters were developed to control automobile emissions. This was a "technical fix." Alternatively, a "social fix" may be imposed, such as laws that limit the number of smoke-emitting factories in a given region to control atmospheric pollution.

Technology also brings on ethical issues, many of them unprecedented. When kidney dialysis technology became available there was not enough equipment to go around. Organ replacement technology presents the same dilemma. Who will be served and in what order? Or, by what right should waste dumps be placed near a particular person's home? Or, should a new drug be released prematurely before all testing is completed if it may possibly help treat an incurable disease?

Technology is a particularly powerful agent of violence. A single terrorist can hold an entire nation hostage. Space weapons may soon change from instruments of mutually assured destruction to space machines for a defense umbrella and in turn change the way nations strategize for war. Nuclear weapons have such awesome destructive power that humans must compare the benefits their threatened use may provide with an unthinkable threat to civilization that is likely if they are actually used.

The nature of our technological society is increasingly marked by such complex dilemmas. Some of these dilemmas may be solved by more technology, some by laws, and still others can only be accommodated by society.

In balance, however, the enormous benefits of technology provide a great incentive to go on developing it and to learn to deal with its dilemmas. One of these benefits is the modern energy system. The amount and kind of energy available both allows and limits human activities, since all processes—including life itself—require energy. Modern human enterprise is dependent on the use of fossil fuels, in engines that convert heat to mechanical work, and in motors, lighting, and communications where their energy has been converted to electricity.

Technology has revolutionized the agricultural system with machinery, fertilizers, and pesticides, permitting not only the growth of human population, but allowing relatively few farmers to feed the rest of the world's people, who are free to work at other jobs. In the U.S., less than 3 percent of the population grows the food.

Health care is yet another benefit that has been dramatically changed by technology, from physical and chemical diagnostics to the wonder pharmaceuticals, to myriad new facilities for patient care.

Most believe we are entering an "information age," where human existence will once again be transformed by our ability to process and communicate information of all kinds—data, words, graphics, and even ideas!

The list of examples may appear endless, but constraints do exist. These include, for example, available energy, land, and material resources. They include also the laws of physics and the social and ethical limits to human endeavors. Further, at any time there may be limited availability of financial

and intellectual capital to develop and control the new technologies. The nature of the technological society is that it may soar with unimagined benefits, but it is still bound by technical and human limits.

Control of Technology by Society

Control over the *development* of technology is in the hands of technologists and investors, public and private. Society, however, has various means for control over the use of technology.

Technology evolves into practice through ideas, designs, and development. It is subject to constraints as noted earlier. It must ultimately meet the requirements of practicality. Those who would invest in new technology and promote its use must consider its timeliness; how it competes in a global market; and of greatest importance, its costs relative to its value. None of these factors is obvious in the beginning.

The practitioners of technology must act in a socially responsible way, avoiding the use of dangerous processes or developing products that can harm. This is no longer a simple issue, because the number of harmful substances is growing and the levels at which they can be detected now measure in parts per billion or less. What and how much is considered harmful is a changing set.

But society has its own means for control. Manufacturers are subject to the satisfaction of their customers. Harmful substances and practices can be banned or regulated. Public opinion can force limits, even on the instruments of war, for example, the use of chemical weapons.

In a technological society rapidly growing complex, however, the pace of technology tends to outstrip the forces of control and delivers unexpected consequences that will forever be with us. Citizens who would control the use of technology must be technically literate, aware of the technical/social problems, and of alternatives, if their actions are to be well founded.

The central question in the technological world is, "Who will develop and control the technologies so that they can best serve all citizens?" In a democratic society, it seems that a technically literate population provides the best answer.

The Nature of Technology

Concern for the nature of technology has increased as the complexity of technological systems and their impacts on humans, society, and the environment have become more evident. Throughout the world an awareness of the need for a more sensitive, intelligent, and technologically literate citizenry has become evident. In efforts to address the question of technological literacy, a new awareness has emerged, namely, the limited understanding of citizens of the nature and meaning of technology. The purpose of this section is to address the question of the nature of technology.

Technology in History

The history of human societies during the past 10,000 years can be explained in terms of successive technological revolutions. These include societies identified by terms which describe their technological base, such as hunting and gathering, horticulture, irrigation, agrarian, agriculture, industrial, and post-industrial. The transition from one form of society to another became major turning points in the history of civilization. Each turning point represented a significant breakthrough intellectually in the development and use of adaptive systems and technical means consisting of tools, techniques, and technical systems.

The successful creation of adaptive systems and technical means* is a complex human activity dependent on many factors, many of which must operate concurrently. A number of constraints limit the creation and adoption of technical means within any given society. Understanding these constraints and the process of creation and adoption of technical means are critical elements in the technological literacy equation. Among the constraints limiting the creation of technical means include:

- The size of the information and knowledge reservoir
- The intellectual and social climate in which the inventor lives and works
- The level of technical talent and expertise available
- The level of development of associated technologies and technological systems
- The social compatibility of the innovation or invention
- The economic capability of the society to support the development (De Vore (b), p. 27).

Whether a new tool, machine, or technique is created and adopted is a function of the human intellect and human choices, made consciously or unconsciously.

Technical Means Today

Today, the relation between humans and their technical means is a totally different relation than existed in any previous society. Not only have the components of the various technological systems changed, there has emerged also an increasing capability to create and use technical means, a greater dependence on and awareness of technical means, and an accrual of a large and growing reservoir of technical objects and procedures.

Most people are aware of the significant changes that have taken place in their society. Yet, most continue to perceive technical things in purely instrumental ways, as means to ends. This traditional view has limited the possibility of gaining insight into the true nature of technical means. Martin Heidegger and José Ortega y Gasset believe that the *being* of humankind and the *nature and character of technical means* are directly and intimately related in the ongoing process of life. Gasset says that humans must act in order to be and that *being supposes action* (p. 116). Technical means are a part of a person's being and the creation and use of technical means provide new contexts in which humans exist and have their being. Technical means serve as a mediating element as humans interact with their environment in the act of becoming. The greater the difference between one era and another, the greater the difference in the way humans experience the world and the way they perceive nature and the character of their created technical means.

Implied in this perception of the nature and character of technical means is the understanding that life is oriented primarily toward action, not contemplation and reflection only. Life is thinking

*The terms *technical means* and *adaptive systems* are used in place of the word *technology*, reserving *technology* to designate the discipline and field of study.

and creating. To live is to be in the process of self-creation, a process enhanced and made possible by the creation of technical means. The world encountered by humans depends on how they have created the world and how they structure it cognitively. How they create the world, therefore, depends on what they encounter (Hood, p. 354).

Human endeavors in the creation and use of technical means are concerned with systems of knowing and doing. It is through these systems of knowing and doing that humans encounter and structure their world. Technological activities are fully within the human context and a natural part of it.

Perceptions of Technology

The nature and character of technology has evolved over centuries as have people's perceptions of the meaning of the word. Viewpoints about technology range all the way from technology as things or tools only, to technology as a major component of the adaptive systems of society. Technology brings to mind such concepts as skill, craftsmanship, artifacts, technique, work or a system of work, engineering, a body of knowledge, a discipline, a system of means, or an effect. Each of these viewpoints has contributed to a more complete understanding of the nature of technology as well as adding to the confusion. Even the standard definitions of technology tend to cloud the issue.

There are numerous definitions of the word *technology*. Dictionary definitions range from the branch of knowledge that deals with the industrial arts, applied science, and engineering; to the science of the application of knowledge to practical purposes; to the totality of the means employed by a people to provide the material objects of their culture. Some writers never define the term; they assume a common meaning. Others define technology from the perspective of their discipline. For instance, economists define technology in reference to production; sociologists, from the perspective of social relations and political structures; and engineers, in terms of physical structures or technical systems. If there is an agreement, it is that technology is woven into the entire fabric of society.

The Context

Any given definition is meaningless unless the context in which the definition is grounded is known. The evolution of the meaning of technology parallels changes in the perception of the manifestation of a society's technical means. In early civilizations, technical means were manifested by simple tools, later by instruments and machines. At each stage of creation and development, the tool, instrument, or machine became more independent of direct human action. Increasingly, mechanical action has been replaced by electronic or physiochemical processes, with the result that there has been a continual alteration of perceptions about technical means.

However, perceptions are not always accurate, particularly in an era of rapid change where the technical means has become increasingly complex. There is a tendency, for instance, to assess the meaning of new technical means in the context of the old. The mechanical era of gears, cams, wheels, shafts, and visible systems was relatively easy to observe and comprehend. Today's systems, based on electronics and nonobservable functions carried out by the flow of electrons are not easily understood. The easiest approach for many is to interpret the new in terms of the old and label everything with the generic metaphor *the machine*. This approach assures that the true insight and meaning of human creativity in the technologies will not be known.

An Alternative View

The diverse and conflicting viewpoints about technology are of little help to those concerned with public policy, education, and technological literacy. They only increase the confusion and dissonance. With no common agreement on meaning, it is not possible to pursue intelligent public policy, develop valid curricula, or establish programs to attain given levels of technological literacy. Therefore, it is necessary to establish an agreed upon meaning that has universal usefulness and identification. The alternative that meets this criteria is to focus on technology as a field of study, as a discipline. This is particularly appropriate when questions concern education and curricular issues. It is also appropriate for general discussions because the word *technology* is then placed in the same category of meaning as are terms that designate other fields of study or discipline, such as sociology, anthropology, physiology, biology, and psychology. Other words and terms are then used to identify elements within the discipline. If one is talking about transportation, terms such as vehicles, propulsion, guidance, and other more precise terms are used. If a general or generic metaphor is required, then the terms adaptive systems or technical means can be used (rather than technology) to describe tools, mechanisms, techniques, or technical systems. This approach provides a much clearer meaning as to what one is talking about.

Technology and Science

Most unabridged dictionaries define the word *science* as a branch of knowledge or study dealing with a body of facts or truths *systematically determined*, or as *systematic* knowledge of the physical, material or natural world. There is general agreement that science means not one branch of knowledge, but numerous branches of knowledge such as psychology, anthropology, geology, biology, and other -ologies. The common factor shared by all the physical and biological sciences is the *systematic determination* of facts, truths, and knowledge.

Swyt, in his analysis of the issue, compares the theoretical entities and relations governing the phenomenon of Newton's Mechanics in the physical sciences with a formal description of the created phenomena of a technical device, PIPE (a pro-

grammable parallel-image-processing-engine) developed within the robotics program at the National Bureau of Standards. In this endeavor, the body of facts, knowledge, and understanding were *systematically determined*. The creation of a technical means follows a specific order according to Swyt, namely: (1) the idea of the technical means as phenomena; (2) the conceptual theory of the technical means; (3) the mathematical formalism by which the behavior of the technical means is calculated; and (4) the empirical realization of the technical means as an observable, operational system (Swyt (a), p. 5).

The Discipline of Technology

Given this as a base, what does the study of technology involve? What would a person study to be technologically literate? Approaching the question from the many diverse viewpoints and definitions of technology would provide no common agreement or common ground for discussion. However, new meaning and a clarity of focus is provided when technology is perceived of as a discipline and as one of the sciences with a body of knowledge that has been *systematically* determined.

In this context, technology is a discipline whose practitioners are involved in the *systematic* study of the *creation, utilization,* and *behavior* of *adaptive systems* (tools, machines, materials, techniques, and technical means) and the behavior of these elements and systems in relation to humans, their societies, and the life-giving and life-sustaining environment.

Given this context, a technologist might be involved in any number of activities ranging from:

- Creating technical devices, means, or systems
- Utilizing specific technical means
- Studying the behavior of various technological systems
- Identifying the impact of various technical means on human beings, their society, and the environment.

A technologically literate person would have knowledge about and understanding of these primary elements. Curricula and programs of study designed for the purpose of attaining technological literacy would contain the essential elements denoted by these four primary fields of endeavor. Briefly, these *essential elements* would consist of, but not be limited to, the following categories of knowing and doing:

- The history, evolution, nature, and development of technical means, including knowledge of people, places, and cultures where the means were invented and developed.
- Knowledge and understanding of the processes of invention and innovation, including experience in the process.
- Knowledge and understanding of the behavior of adaptive systems and subsystems, such as communication, production, and transportation, and the tools, machines, materials, techniques, and energy conversion processes associated with these systems.
- Knowledge and understanding of the behavior of various technical elements and adaptive systems, and the assessment of the impact of these elements and systems in relation to the humans, their societies, and the environment.

The *essential elements* of the discipline of technology are systematically determined by the creative endeavors of humans. The discipline has a history, a body of knowledge, and derived intellectual processes and procedures. Knowledge and understanding of these *essential elements* are central to the preparation of liberally educated citizens for a democratic society.

Summary

The actions of humans in the creation of adaptive systems and technical means have provided the means that enabled humans to survive in all climates on this planet and in outerspace as well. This creative process is an essential part of being human. Changes in the technical base of a society have altered perceptions as to what it means to be human. They have also altered perceptions as to the meaning of technology, particularly in recent times. Technology has been used to mean many things to many people, quite the opposite of other -ologies. In a general way, technology has been used in place of more accurate terms, such as adaptive systems and technical means. If the goal is to determine the nature of technical means or adaptive systems, then the focus must be on these elements and their behavior and the relation of these elements to humans, their societies, and the life-giving and life-sustaining environment. The nature of the discipline of technology is determined by analysis of the content and structure of the discipline and the behavior of its practitioners. This approach to determining the nature of technology provides a focus and direction that enable the establishment of a clear agenda for determining policy and pursuing questions concerning education, curricula, and technological literacy.

The Curricular Role of Technology Education

Technology education may assume many roles in the curricula of the present and future educational systems. It may be an area of study that assumes its own posture as a separate school subject largely independent of other subjects. A second posture might be one of appendage to another area such as social studies, science, or vocational-technical education. However, a more vital and valuable role is one of integration within the middle, junior, and senior high school.

This integrating role for technology education is based on the concept that the school ought to be the setting where the student can put all the parts (academic disciplines) together in the context of reality and the world beyond the school. This concept is supported by Alfred North Whitehead in his book, *The Aims of Education* (1952), in which he spoke out against the "fatal disconnection of subjects" in the following comment:

> The solution which I am urging is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject-matter for education, and that is life in all its manifestations. Instead of this single unit, we offer children—Algebra, from which nothing follows: Geometry, from which nothing follows; History, from which nothing follows; a couple of languages never mastered. . . . It is a rapid table of contents which a deity might run over in his mind while he was thinking of creating a world, and has not yet determined how to put it together. (p. 18)

Whitehead summarized his position by stating that "the pupils have got to be made to feel that they are studying something and not merely executing intellectual minutes." (p. 21)

The Technology Education laboratory, along with the nature of activities associated with it, is the most appropriate setting in the school for such an integrating function to take place. It is a setting wherein the areas of science, mathematics, social studies, environmental studies, history, geography and philosophy can find relevance and meaning in a context that brings the world, into the school and takes the school out into the world. This idea is supported by Truxal (1986) who stated:

> As technology is directed toward a societal goal, every new technology involves questions of ethics and values, which must be judged from aesthetic, historical and philosophical viewpoints. Furthermore, technological change has economic, sociological and behavioral implications for both the country and those individuals directly involved. (p. 12)

The interdisciplinary nature of Technology Education is inherent in its content and strategies for instruction. The economic, social, environmental, and ethical questions associated with its pursuit in the educational system amplifies the importance of this role.

An additional dimension of this concept is centered around the proposition of "holistic learning." This proposition is based on the idea that the learning processes should be centered around the whole of the subject and not an atomistic approach that deals with isolated parts.

Further support for this integrated, holistic role is in the idea that it is impossible to teach anything to any substantial degree within a single discipline.

Thus the curricular role for Technology Education can and must be one that provides for an integrated, holistic approach to education in the 21st century.

Technology Education also has some important roles to play with respect to the development of the individual and helping him/her to live effectively and to contribute in a society so profoundly influenced and impacted by technology. These roles are discussed in the following sections.

Helping Students Understand Their Technological Future

The schools at all levels have an important role to play in the process of helping students understand their technological future. In many respects, this is a new role for the schools and the educational system. Much of what is taught in the schools deals with current and past developments in the several

disciplines. Education has tended to look back instead of forward. It characteristically has been a reactive institution. The school must become a pro-active agency in its dealing with the study of technology and its implications for life in the 21st century and the centuries that follow. This will require a kind of technological literacy that embodies a form of "anticipatory education" and a sensitivity to the kind of decisions that need to be made to ensure a future for the generations to come.

The schools can and must play a prominent role in defining the kind of a future present and future citizens will have. The development of a high degree of technological literacy through our educational system is an imperative in a technological age in which it is possible to design the kind of a future that is wanted or needed.

One of the keys to helping students understand their technological future centers on the nature of the content and, in particular, the nature of the questions raised. The issue is one of seeing the impact of technology on the present and future, and then making appropriate inquiries with respect to its use and value.

This point was made by Boyer (1983) in his book titled, *High School: A Report on Secondary Education in America*, as follows:

> The great urgency is for "technology literacy," the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning how to use the latest piece of hardware, but asking when and why it should be used. (p. 111)

Other appropriate questions may include the following (Maley, 1987):

- What are the alternatives?
- What is the social impact?
- What is the environmental impact?
- Who should be involved in the decision?
- What role has the technology or the innovation played?
- What is the long-range impact?
- What are the ethical, moral, and legal issues associated with the technology?
- Who should pay?
- What if? (p. 190)

Raising such questions is not to present a negative perspective on technology. Rather, it is to provide a more analytical view of the technology under consideration so that the result may be a better understanding of the technological item, system, or development.

One of the keys to helping students understand their technological future is to stimulate interest in it. The exposure of students to Technology Education is the first step in the process of developing interest. However, this exposure must be appealing to the student and in a context that establishes meaning and relevance to what is being studied. Designing learning activities and constructional experiences in which the students have input as well as a great deal of personal involvement are other interest-builders.

Exposing children in the early grades to interesting and exciting activities with Technology Education is a good start for continuing interest by upper-grade students. Whatever is done must be in a context that value in such studies is evident and that the students can clearly see it as such.

The extent to which the students are able to understand their technological future is, in many ways, dependent on the development of learning processes and skills in processing information. The issue here is one of optimizing the student's capability to assimilate, understand, and carry on the processes of reflective thinking as well as decision-making. One of the secrets to this important learning development is the kind and level of involvement that the student has with the study of technology. The Technology Education laboratory provides a setting that abounds with opportunities for a broad range of learning activities extending from the concrete to the abstract. The opportunities for inquiry, problem-solving, synthesis, and decision-making are in good quantity and quality in the technology laboratory and its associated facilities.

The potential for problem-solving and the development of reasoning skills are fundamental to an activity-based Technology Education experience in the study of technology, as well as to the development of an understanding of the technological future.

The nature of learning and the role that the study of technology played in fulfulling the dimensions of such a process, was the concern of a comment in the National Science Foundation publication, *Educating Americans for the 21st Century*. (1983)

> True learning includes first, a sense of accomplishment and satisfaction, second, an excitement which generated further exploration, and third, a desire to relate this new ability to other areas. It is our position that the study of technology can stimulate this cycle and foster true learning in science and mathematics as well. Beyond all practical reasons, we encourage the study of technology by young people strictly for the simple joy of it and for the great satisfaction that comes with an understanding of how the world works. (p. 84)

A final point in this discussion of helping students understand their technological future deals with establishing a student-technology relationship.

The words *relevance, meaning,* and *significance* are dependent upon what may be called a student-technology relationship. It is the personal affinity that can be developed which will, in a large measure, determine what is learned and what is understood. The ability to establish linkages with personal interests and concerns and the dynamics of technology are some of the building blocks in the process. The utilization of interests and the building on concerns contribute to the student-technology relationship. The interests may be related to a possible career, a technical fascination, or a curiosity unanswered. The concern may be the trend of affairs on the national and international fronts, energy sources, water supply, quality of living, congestion of cities and highways, or personal privacy in an advanced technological society. The role is obviously one that the educational system must take on. It is a role of helping the students understand their technological future through Technology Education.

Technological Literacy through Technology Education

One of the goals of Technology Education is technological literacy of a broad and encompassing nature. Technology literacy in the context of this presentation is that understanding of technology—its evolution, its utilization and its significance—which would enable the individual to function effectively as a citizen as well as in those specialized roles that one plays in a given society.

The nature of understandings required for technological literacy is related to such factors as time, place, and conditions. The *time* element may be illustrated by contrasting the level of technological understanding available to or needed by the Pilgrims of 1620 as compared to the current (1988) residents of Plymouth, Massachusetts.

The *place* factor with respect to technological literacy may vary for those living in the 20th century when one considers the living requirements of the primitive natives of New Guinea compared to the citizens of New York, Chicago, or Baltimore.

The *conditions* variable may be illustrated through a comparison of the technological literacy needs of the space personnel, or astronauts with those who reside in the comfort of their homes on Main Street, U.S.A.

The National Science Foundation publication *Educating Americans for the 21st Century* (1983) contains five important areas of understanding of technological literacy for the present and future citizen. These areas of understanding are:

- The historical role of technology in human development
- The relationship between technological decisions and human values
- The benefits and risks of choosing technologies
- The changes occurring in current technology
- An understanding of technology assessment as a method of influencing the choice of future technologies (p. 74)

These five areas are fertile ground for programs in Technology Education. As a matter of fact, there are Technology Education programs in existence that address these points in a meaningful, relevant manner at the middle, junior, and senior high school levels. These five areas of technological literacy address vital citizenship requirements for effective democratic participation in the United States, present and future.

Participating in the Democratic Process

The study of technology and the development of technological literacy are imperatives in this latter part of the 21st century and particularly so in a democracy. This imperative calls for knowledge and skills necessary for effective living in the present and future. It also calls for an active participation on the part of the citizenry with respect to matters dealing with technology—its selection, its use, and its impact. Thus, knowledge about technology, skills in its use, and an active participation of a technologically informed citizenry become essential if the public interests are to be served.

Knowledge is the basis for democratic participation. This fundamental principal becomes more important in a rapidly changing technological society where the impact and consequences may be vital to one's survival. Technological decisions may have broad social impact, affecting the family structure, community, national, and international functioning.

Likewise, the economic impact of technology may be on a personal basis, or it may influence the broader dimensions of communities, nations, and the world. The daily economic impact of technology on the individual is present in the purchase of food and commodities for the home, the pursuit of one's wage earning, travel, communications, and consumer activities. On the broader scale, technology plays an important role in economic development, business, industry, commerce, and government. Innovations in production—involving material-handling processes, robots, computer-assisted drafting and machining, advanced form of communications, systems integration, and quality control—are part of the technological tidal wave that also can be a part of Technology Education.

Knowledge of the environmental impact of technology is another prerequisite in a democratic society. This involves those forms of technology that have potential for enhancing the environment as well as those that would harm or destroy its usefulness. The issue of environmental impact of technologies is heightened by the short- and long-

termed consequences that may extend into days, months, years, or centuries. The knowledge of technological impact by the citizens of today may actually be the key to the nature of the environment for generations to come.

But knowledge alone, although essential, will not suffice. The citizen must have skills and competencies that make use of the knowledge of technology and the role it may or may not play.

The skills in *getting information*—in *identifying* sources of information as well as *accessing information*—are basic to human performance in the present and future. The citizen must also be able to *evaluate the information* in terms of personal or broader societal influence. This evaluation skill may lead to more effective *choosing among information* so that effective decisions can be made. Another area of skill development that may grow out of a good program of Technology Education would be related to *data and information analysis*. This can only come about if one has the background and information regarding technology to make the necessary analyses.

Technology Education provides the citizen with background and understanding vital to his or her involvement on local, state, and national levels. The content of Technology Education is essential in the present and future society as the individual functions in a variety of roles. These roles involve the citizen as a voter; an office-holder; a participant in public interest committees; a member of political coalitions, appointed councils, or commissions, and as an advisor to government officials. These citizenship roles place a strong mandate on technological literacy, for many of the critical issues of the future will involve sophisticated perceptions and astute decisions related to technology.

Life in this latter part of the 21st century is integrally entwined with the heritage of technology. The miracles of construction, transportation, medicine, communication, entertainment, and manufacturing provide the setting and the means for living and growth of individuals and societies. These among many others are the products of a technological nature produced by humankind, and which provide the support as well as the challenge to existence in this period, unparalleled in the history of the human race.

Technology Education is the program area dedicated to the proposition of an enlightened and effective citizenry in an advanced technological society. What's more it has the capability to carry out this worthy idea.

Citizen Participation in Matters of Technology on a Personal Basis

Personal living in an advanced technological age makes many demands for increased understanding of technology that may be achieved through programs in Technology Education. Specific roles of the individual requiring a working knowledge of technology and a level of technological literacy are as follows:

- *As a user* of technology in the home, in recreation, in self-development, travel and daily routine.
- *As a purchaser and consumer* of technology ranging from automobiles to radios, televisions, computers, lawn mowers, refrigerators, boats, toys, games, household fixtures, smoke alarms, microwave ovens, telephones, and countless others.
- *As a decision-maker* about technology in the home, community, workplace, educational institutions, places of worship, and public office.
- *As an employee or worker* in the home, farm, factory, business, hospital, schools, media center, public agency, and a broad spectrum of private and public institutions.
- *As a planner* for the future, whether it be a personal project, a public enterprise, or an industry-business proposal.

The individual's involvement with technology and his or her understanding of technology vary in accordance with the part one plays in society. For example, there are those who will be instrumental in the creation of technology. This may require highly specialized information and technological background in a technical sense, but also a sensitivity to Technology Education that deals with the social and environmental impacts of such developments.

Personal Qualities as Expectations from Programs of Technology Education

One of the ways to evaluate as well as plan an educational program is to identify the human expectations to be derived from it. Technology Education programs can and should be directed toward the following personal qualities or characteristics:

- The individual is capable of coping with technology and is not threatened by it.
- One appreciates the contributions made through technological developments.
- The person is sensitive to the pluses and minuses of technology.
- The individual is aware of the need and value of technological literacy.
- He or she is aware of the role technology will play in shaping the future.
- The person will have an open-minded approach to technologically impacted issues.
- The individual will be informed on sources of

information regarding technology.

- One will develop a sense of being in control with respect to the direction of technology.
- The person will develop a feeling of involvement as a contributor and participant in a technologically impacted society.
- The individual may well use Technology Education as a factor in career selection as well as a contributor to occupational performance.

Technology Education as a vital dimension of contemporary education is a program whose time has come. It is not just a matter of timeliness. It is a program of great necessity if the precepts of democracy in an advanced technological society are to prevail.

Individual and Society Benefits

The individual benefits vary in accordance with what is deemed important to the person. Technological literacy to some provides the background for a feeling of involvement as a participant in a technologically impacted society. It is a basis for contribution to society for others, while still others may use it to advantage in occupational performance, career selection, or in personal entertainment. There are economic returns from technological literacy for some based on selection, use, and applications made of such understanding. To other individuals, it may be a matter of a fuller life through understanding and application of life and living in America in the 21st century.

The societal benefits range over a broad number of areas and issues. Some of these would include: a richer more abundant society for all; a safer society with respect to work, travel, and recreation; a cleaner and more healthful environment; a more human existence with a greater fulfillment of human potential; a longer and healthier life for many; an improved lifestyle; a more productive society; more industrial capability; an improved global community; and a better informed society in practically every area of knowledge.

Technology Education is an important curriculum breakthrough. It is an imperative for meaning and effectiveness in a technological society for the individual and all of humanity. To neglect the study of Technology Education is to further enhance the present state of technological ignorance. This is a direction citizens in a democracy can not afford to travel.

Teaching Technology in Our Schools

Technology Education is the school discipline for the study of the application of knowledge, creativity, and resources to solve problems and extend human potential.

The teaching of technology—with its goal of technological literacy—is in its infancy in our school curricula. Still, the nucleus for such activity can be found in many states. Curriculum, learning activities and methodologies are being researched and practiced with success. Numerous states have even developed educational guidelines which promote the attainment of technological literacy. The majority of this work is being implemented in our schools under the name of Technology Education.

What is Technology Education and where in the educational system should it be offered? What form or forms should it take? There are answers aplenty. To understand the above definition, a systems approach has been used as the basis for the following observations about people, technology, and our society.

- Technology has changed and will continue to change society.
- Complex societal issues have evolved from technological developments.
- Citizens must be prepared to understand technological innovation, the productivity of technology, the impact of technology on the quality of life, and the need for critical evaluation of societal changes resulting from technological advances.

The accompanying model for studying technology shows how human wants and needs are addressed through the study of technology. In this case, human wants and needs are the educational and motivational needs of the learner.

Technology Education programs are designed to acquaint all persons with their technological environment so they can make informed decisions about their lives and eagerly participate in controlling their own destiny. These programs recognize the individual's inherent potential for reasoning and problem solving, for imagining and creating, for constructing and expressing with tools and materials from which technology and industry spring. Technology Education capitalizes on this rich potential with content and experiences to contribute to the growth and development of human beings. Thus, Technology Education has become a basic and fundamental study for all persons, regardless of educational or career goal.

Such programs have been designed to help students to:

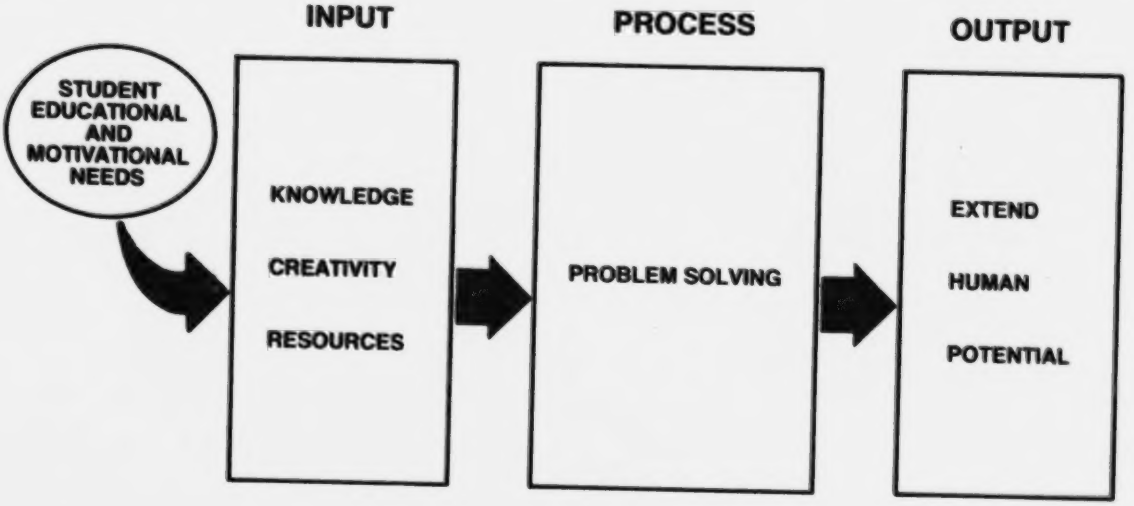
- Know and appreciate the importance of technology
- Apply tools, materials, processes, and technical concepts safely and efficiently
- Uncover and develop individual talents
- Apply problem-solving techniques
- Apply other school subjects
- Apply creative abilities
- Deal with forces that influence the future
- Adjust to the changing environment
- Become a wise consumer
- Make informed career choices

Criteria for a Technology Education Program

Technology Education programs are organized around a set of concepts, processes, and systems that are uniquely technological. For example, students may study about the many aspects of transportation systems to gain core knowledge about its development, effect on people, the environment, and culture. Other technological areas of study may include the vast field of communications including the efficient use of resources to transfer information to extend human potential, or such areas as construction or manufacturing. The topics studied are limited only by one's imagination and could include medical technology, pollution, energy, housing and more.

The program and course content of Technology Education classes assists students in developing insight as well as a rudimentary understanding of the application of technological concepts, processes, and systems. Using hands-on activities, laboratory projects are completed applying tools, materials, machines, processes, and technical concepts safely

A Model of Technology Education



and efficiently. Such activities have ranged from the development and repair of solar collectors to building a model rocket for testing purposes.

These activities develop students' problem-solving and decision-making abilities involving human and material resources, processes, and technological systems. Students are prepared for lifelong learning in a technological society because they are exposed to activity-oriented laboratory instruction that reinforces abstract concepts with concrete experiences. This combined emphasis on "know-how" and "ability to do" in carrying out technological work transforms mathematical and scientific principles into reality.

Technology Education at the Elementary School

Technology education programs have been designed for implementation at all levels in our schools. Programs at the elementary level, grades K–5, have a deliberate focus on technological awareness. Classroom activities are oriented around the development of motor skills and provide the basis for informed attitudes about technology's influence on society. One activity of much interest is a unit on space technology. During this study students develop strategies for colonizing the moon, complete construction activities dealing with flight and share in the dreams of NASA space ventures.

Technology Education projects at this level are integrated into the total elementary school curriculum with the activities and experiences reinforcing the existing curriculum.

Technology Education at the elementary level:

- Provides opportunities for children to learn fundamental concepts on how people create and control their environment
- Reinforces and enriches concepts in the sciences, mathematics, language arts, and other subject areas in the elementary school curriculum
- Allows students to work with tools, materials, and technological concepts and processes
- Develops an awareness of technology

Many successful elementary programs have evolved after preservice or in-service training in the integration of Technology Education into the existing curriculum. These training activities prepare the teachers with additional tools, materials, and supplies to accommodate student needs or activity requirements.

Illustration

Community Helpers

Elementary students are often introduced to technology activities through a "community helper" construction project. In this activity, students learn about tools and materials by creating a production line to construct toy vehicles. The toys are modeled after those that may be used in their community—cars, delivery trucks, police vehicles, fire engines, and so on.

To begin, the students are introduced to the concept of the assembly line and the role and responsibility of workers in such a factory. Proper techniques and care for using tools in the project are also covered, if needed. Then, the classroom is divided into production line workstations and students are assigned to each station. When production begins, the vehicles flow from station to station. One station might trace the patterns onto wood, while another station cuts the vehicles from patterns, others attach wheels, and another station paints the assembled product. A quality control station checks to ensure standards are met.

The result is not only a physical product—the toy

vehicle—for the student but a whole series of experiences related to the other subjects in the elementary curriculum. Related experiences include basic skills such as language development, listening, talking, writing, and reading. A new vocabulary is learned pertaining to technology and production. Spelling and writing experiences are related to the activity to enhance the student's communication skills. Mathematics moves from the abstract to concrete objects. Social studies are supported through the study of various transportation systems found in the community. The students may decorate their vehicles in conjunction with art activities and the environment created by many community vehicles may become a point of discussion.

Community helper activites can span to any part of the community and can result in study pertaining to all aspects of the city. Technology related activities provide the motivation and end product of this type of learning.

Space Colonization

Space and space travel holds a fascination for many elementary students. So Technology Education activities have been developed which build on this interest. One activity, which has worked with great success, pertains to colonizing the Moon. Typically the activity begins with a discussion about space and lunar colonization and results in a construction activity where each student designs the type of housing he or she would use if they lived on the Moon. During the project students consider and research the technology required to transport their home to the Moon, the nature of its structure, life support systems needed, and other items which will lead to their comfort while they are inhabitants.

Each student must solve their problem through research in the library or other sources. An endless number of topics and school subjects are utilized as the student studies, designs, and constructs a paper model of their lunar home.

This activity requires the use of measurement devices, consideration of basic science principles, library skills, writing and communication skills and an imagination limited only by the students' potential.

Technology in the Middle School

Students at this level, grades 6–8, thrive on situations and higher order thinking skill development that includes a major focus on explorations in technology. Here, a variety of technological resources can be utilized in problem-solving situations. Opportunity is provided for creating and designing. Activities result in technological awareness, psychomotor development and experiences pertaining to the development, impact, potential, and careers related to technology.

Experience has shown that middle school students are enthusiastic and motivated model builders. Teachers capitalize on this trait by guiding their classes to study inventions of past and present, and possible ones of the future. Timelines are developed showing how innovations such as telecommunications have evolved from the early years of our history. Technological developments such as the automobile or airplane may be traced and individual or group research and construction completed. Computer simulated flight or other attainable computer packages are often included in the learning experience.

Students taking Technology Education at the middle school level will:

- Appreciate the scope of contemporary technology
- Safely use basic tools, machines, materials, and processes associated with technology
- Identify occupational fields and educational programs in technological career fields. Study and analyze the materials, products, processes, problems, uses, developments, and contributions of these related career fields
- Experience the organization and management systems of business and industry
- Research, plan, design, construct, and evaluate problems and projects common to technological career fields

The benefits of experiences like this are extensive. Students learn about construction/fabrication of materials and processes, research practices; the practical use of mathematics, scientific principles and practices; and the interrelationship of society, technology and economics. More important, they learn about themselves by discovering capabilities and aptitudes.

Technology Education activities provide the student at this level with an endless amount of opportunities to create and problem solve. These opportunities are similar to those which will be encountered in their technological future.

Illustration

Elements of Technology

This program starts the students on different learning paths before bringing their experiences together. For example, they learn about basic electronics and how to wire simple circuits. They have experiences building mechanisms, devices, and machines, and they learn to use the computers.

These experiences prepare them for more sophisticated experiments with automation and computer control. Or they become familiar with the graphics capabilities of the Macintosh computer, use computer-aided drawing and word processing programs, and pretty soon they're doing CAD.

Students gain experience in fabrication techniques by making display modules which are then used to showcase their work. They use modular building components to construct tabletop models of gear trains, Ferris wheels, elevators, and traffic lights, which they program and control with computers. Computer-aided graphics programs allow students to design and print their own workstation signs, and to complete detailed scale drawings of portions of the lab.

The class doesn't necessarily work as a group on these units. A number of activities like these may be going on simultaneously at different lab stations.

Future Technology

Studying the future in a technology class is a "natural" since students today will have to be the informed decision makers of tomorrow. In this approach, the instructor's first task is to bring all the students up-to-date on what is happening in our rapidly changing world and its relationship to technology. Next, the students follow a series of activities to enrich their background in technology: They complete daily reports on articles, pictures, or impressions from daily newspapers and weekly periodicals. Experiences are given in the media center allowing practice in locating information pertaining to various technologies that affect their lives socially and as consumers. Finally, the students work on displays giving a visual picture of happenings in technology. These displays are changed every week by the students as a result of their information gathering.

Student construction activities are then designed around ideas that the students develop from their research. Topics have included:

- Lasers
- Robotics
- Optic fibers
- Photovoltaic cells

Projects are designed by the students using basic drawing and design skills. Projects center around themes such as communications, production, or housing. Students have an opportunity to choose the scale, processes, procedures, and materials to build a model pertaining to their research. Decision-making and problem-solving become an important part of this hands-on experience. While the model is being completed, reinforcement of other activities occurs, such as finishing indepth research and preparation for presentations.

The finished research is exhibited for the parents and community members. The displayed project and research become a part of the total educational experience of the student allowing them to explain their ideas and concepts to others.

Technology in the High School

Programs at the high school level, grades 9–12, are designed to create outcomes related to scientific principles, engineering concepts and technological systems. The courses provide students with an in-depth foundation for career preparation at the secondary and postsecondary levels.

Students planning to pursue engineering or science in college gain much from taking selected Technology Education courses. Also, students will develop transferable skills for life or further education. This program compliments the middle or junior high school curriculum and offers sequential courses that build on previously learned content without repetition much in the same way that senior high math or science courses build on the introductory courses offered in earlier grades.

Students at this level will:

- Experience the practical application of basic scientific and mathematical principles
- Make decisions about postsecondary technology careers, engineering programs, or service-related fields
- Make decisions about advanced technical education programs
- Gain an in-depth understanding and appreciation for technology in our society and culture
- Develop basic skills in the proper use of tools, machines, materials, and processes
- Solve problems involving the tools, machines, materials, processes, products, and services of industry and technology

Courses dealing with research and experimentation/design have been introduced at the high school level. Students do an in-depth investigation of an area of interest to him or her. Activities have included research in such areas as home (heat and cold) insulation materials, pollution control devices, structural component design, and product comparisons. Other studies have been oriented to both individual and group experiences depending upon the goals of the class and the direction of the instructor.

The teaching of technology at the high school level has been organized in numerous ways to address the many aspects of technology. Programs have been established around emerging megatechnologies, technological issues, frontiers of science and technology, and technical adaptive systems. Whatever the approach, the current trend in Technology Education is to use a systematic study developing broad and useful understandings for a more technologically literate citizenry and productive society.

Illustration

Technology-based Subject Matter

Technology instruction at the high school level is frequently divided into conceptual areas such as energy use, production, communication, and transportation. Each area provides students with general knowledge and understanding about technology. Students use equipment such as computers to solve technical-related problems such as cutting speeds and characteristics of materials in the construction of their projects. Many students are required to complete a technical project (i.e. production of a product using polymers) in addition to working on a technology model.

Students may select a project idea such as

- Solar planes
- Self propelled systems
- Wind generators
- Zero gravity manufacturing
- Computer design applications
- Laser Technology
- Robot/Computer interface

To accompany the engineering of the model, each student develops a paper that explains the social need of the technology model, the operating features on the model, and ways the model could be further developed.

Additional courses are often offered in areas such as production where students form a company to process materials and a final product. Many approaches may be used to help students comprehend a worker's role in contemporary manufacturing. Students may work on many activities such as making minor adjustments to a pick-and-place robot that places plastic sheets in an oven and then removes the sheets and places them in a forming mold. Such projects involve hot materials and illustrate how robots can be applied in production for safety. Other experiences pertaining to quality control, conveyor systems, and personnel problems are all a part of the production experience.

Summary

The advent of Technology Education in our schools has created a new dimension in the education of our children for the years ahead. Never has such an opportunity existed for a school discipline designed to ensure that citizens are prepared to live in and contribute to a competitive and technologically based society. Work is continuing to refine content, teaching techniques, developing industry/education linkages, and more with the purpose of enhancing the teaching of technology in our schools. Successes are being experienced in terms of student motivation and the enhancement of math, science and other school subjects. The end result will be a more educated populace which will provide our country with the competitive edge necessary to remain as one of the most productive nations in the world.

A Call to Action

Technology is a part of everyone's daily life. Even so, most people do not even begin to comprehend the complexity of our technological society. The preceding parts of this paper have described the nature of technology and have demonstrated that society changes technology, and it in turn changes society. A need for school curricula to include a requirement that all students learn about technology has been presented. This learning should not be incidental but should have a direct focus on technology. Emphasis was given to the central need for a good, basic education as the vehicle which should include Technology Education.

The issue here is not whether Technology Education is good or bad; not whether it should or shouldn't be offered; or not how it is to be taught. The issue here is whether the United States will maintain its worldwide competitive lead in technology. If it does, our standard of living remains good or improves. If it does not, our quality of living goes down. And when it goes down, the United States becomes a second-class nation. If that thought is disturbing it is nonetheless true!

The solution to the problem is not one that can be solved by parents or the schools alone. This is not solely a school curriculum problem or a parent-child issue. The problem is one that affects our total society and must be addressed by all segments of it. We cannot spend time finding scapegoats. We must get to the job of restoring to the United States its competitive edge in technology. But more importantly, we must provide a form of education that will help our citizens live optimally in an advanced technological society.

The U.S. has never been afraid to tackle large problems. As far back as 1862, Congress passed the Morrill Act which resulted in our development as the most advanced agricultural and engineering nation in the world. When the Russians developed their Sputnik rocket in 1957, we responded by passing the National Defense Education Act (NDEA) which improved all types of school curricula, as well as funding our space program. If those problems were solved (even if temporarily), this one can also be dealt with effectively. A broad-based, frontal attack is called for. Following are selected agencies, organizations, or groups that can help and what some of their initial actions can be.

Parents

Parents can be prime movers by ensuring that their children become informed about technology. They can do this primarily by insisting that their children's schools include Technology Education as a central curriculum theme. Secondarily, they can take their children to technological installations for visits. Museums and industry tours or exhibits provide direct knowledge about our technological society. Efforts should be made to discuss current events from newspapers, magazines, and television programs of educational value. Student experiences which involve hands-on activities related to contemporary technology should be encouraged. Such experiences may include science or technology oriented competitions or involvement in simple problem-solving activities around the home, school, or community. Technology experiences can provide realistic challenges to all ages and ability levels related to every type of environment.

School Administrators/Boards of Education

School administrators and boards of education are in "gate keeper" roles in terms of strengthening Technology Education programs. Their leadership and dedication in the creation of stronger Technology Education programs can serve as the primary motivating influence to teachers and supervisors seeking and needing support to produce outstanding instruction. Such leadership can serve as the foundation for an enthusiastic curriculum and program experience enhancing everyone's technological literacy.

Our school leaders have the legal responsibility to assure that a curriculum prepares students to live effectively in their technological society. To ensure our nation's place as a leader in an ever-changing technological world, we must develop our human resources and demand technological experiences that instill insight, drive, and efficiency. Emphasis should be placed on educating people to think and

act from a technological perspective, for therein lies our strength.

School leaders can assist by making every effort to become more familiar with technology issues. This might involve attending programs at various conferences, serving on advisory groups, and organizing events which will allow other constituency groups to be more informed about Technology Education.

Government and Legislative Bodies

Our nation's government and political leaders have a key role to play in the technological literacy levels of our country's population. First, these leaders must apprise themselves of the critical role that technology plays in the economy of each state as well as our nation vis-a-vis Technology Education. While legislators must not determine the curriculum content for the public school, they can express to school leaders their interest in Technology Education and its role in creating a statewide climate for technological development.

Funding is needed for the creation of exemplary Technology Education centers throughout the country. Leadership is needed to increase the level of technological literacy because businesses, military superiority, and the very economy itself depend upon an educated populace. Initial legislation has been written and testimony given. The need is clear now for a stronger role to be created for Technology Education in our schools that goes far beyond the use of computers to include the evolution, appropriate use, and significance of technology and its social/cultural impacts on our country. Our political leaders *must* become the spokespersons for this type of education.

Professional Education Associations

Education associations need to unite around the recognition that Technology Education, broadly conceived, occurs in many classrooms and areas of the curriculum. Comprehensive programs, preschool through adult, provide instruction that ensures all students the opportunity to achieve technological literacy. These programs should be promoted as playing a key role in the enhancement of math, science, and social studies instruction in our schools.

The teaching of technology and its application toward solving society's problems has in a sense become "the new basic" due to our fast-moving, highly sophisticated society. Educational organizations should make every attempt to learn about and promote contemporary Technology Education for the good of the students in our schools.

Corporate Executives

Corporate leaders have many key roles to play in the promotion of Technology Education. Their influence in both state and national legislation can bring attention to the need for informed workers with a technological background appropriate for tomorrow's industrial/technological world.

Corporations can also promote teaching technology by assisting educators in public relations efforts, both print and non-print. This support allows for better communications to various publics, which can enhance the message for more and improved technology instruction. Corporate leaders are often ideal spokespersons for education and should not hesitate to speak in support of deserving programs.

Boards of education and advisory groups are always in need of outstanding individuals from corporations as members. Knowledge pertaining to the technological world is important to these education groups and eventually affect the type of employee that works for the corporation.

Technical assistance and student access to selected technological field trips can enhance education for both instructors and their students. Technology teachers need corporate involvement to stay apprised of latest developments. Students need to experience the procedures and technological processes which can only be provided by field trip experiences or dialogue between corporation personnel and the students. Opportunities for this type of educational experience should always be explored.

Were all of the foregoing to be accomplished within the next year, would the U.S. be more technologically competitive? Possibly!

This paper has proposed directions for individuals to create better solutions to human problems, make informed decisions, and exercise improved control over the environment. It has been proposed that Technology Education should result in a person who (1) adjusts to the changing environment, (2) deals with forces that influence the future, and (3) participates eagerly in controling his or her own destiny.

There are no quick fixes, no cure-alls. The effort will have to be sustained over a period of years by individuals from many positions in our society. Funding, consultation, advocacy, and curriculum development will all require a concerted effort if a difference is to be made. And that difference must make a difference in the competitive edge held by the United States. Our citizens expect no less. Our students deserve much more. The time for action is now.

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Acknowledgements

Special acknowledgement is given to the following persons who played an important role in the creation of this publication.

Forrest D. Brummett
Paul W. DeVore
Thomas A. Hughes, Jr.
James R. Johnson
Donald Maley
Donald P. Lauda
Kendall N. Starkweather
Dennis A. Swyt
Walter B. Waetjen

And all members of the Technology Education Advisory Council.

Appreciation is also expressed to Greg D. Clouse for his editorial assistance and Peg D. Kirkpatrick for her support in making the final publication a reality.

TECHNICAL FOUNDATION OF AMERICA

This publication was funded by a grant from the Technical Foundation of America.

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Technology Education Advisory Council

The Technology Education Advisory Council (TEAC) was established to provide information to the technology education profession about current developments and possible trends in technology and industry, and the implications of those trends for technology education.

The Council's activities are advisory, it has no official policymaking authority. Topics of discussion vary as the association's membership determines or as requested by the ITEA Board of Directors.

The purpose of the Technology Education Advisory Council is to:

- Recommend ways of resolving any discrepancies between the programs and philosophies of technology education and current industrial/technological practices.
- Recommend content direction to improve the relevancy of technology education.
- Suggest methods of improving the public's perception and understanding of technology education.
- Assist in the cooperation between industry and education to improve the educational process.

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